SB761
U7I5.
#84-3

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FOREST PEST MANAGEMENT

STATE & PRIVATE FORESTRY

INTERMOUNTAIN REGION

3420
Report No. 84-3
February 1984

EVALUATION OF VEGETATION DAMAGE ALONG NEVADA HIGHWAYS IN THE LAKE TAHOE BASIN

by

Jack P. Marshall[1/]

INTRODUCTION

The Lake Tahoe Basin is one of the most scenic areas in the western United States. Vegetation retention and maintenance of this largely visual and recreational resource area is of paramount importance to local land managers. Since the early 1970's, land managers have noted vegetation damage (foliage discoloration and mortality) along the basin's highways and requested biological evaluations to determine cause and extent of damage. Recent reports listed numerous agents including needle diseases (6), highway deicing salt (2,4,7), and root rot (2) as being involved with vegetation decline. Much of this work was done on the basin's west side in California.

Land managers were also concerned with roadside vegetation damage on the Nevada side of the basin. During 1980 a roadside vegetation survey (4) along Nevada State Route (SR) 28 between Incline Village and the Junction of SR 28 and Interstate 50 was conducted by the Nevada Division of Forestry (NDF) and the USDA Forest Service, Lake Tahoe Basin Management Unit (LTBMU). This survey concentrated on collecting empirical information pertaining primarily to extent and degree of apparent deicing salt damage to roadside vegetation. A joint meeting between the NDF, LTBMU, and the USDA Forest Service, Forest Pest Management (FPM), Intermountain Region, was held in October 1980, to discuss the results of the survey and to visit affected areas. Survey results indicated that incidence of vegetation damage was high and the problem severe enough to warrant a thorough biological evaluation of the surveyed area.

Following this meeting the NDF requested that the Intermountain Region's FPM staff conduct a biological field evaluation to determine amount, causes, and

---

1/ Plant pathologist, Intermountain Region, Forest Pest Management, Boise Field Office

LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION

distribution of tree damage (i.e., any observable disease, insect attacks, mechanical injury, road salt damage, etc.) and mortality along Nevada SR's 28 and 431 in the Lake Tahoe Basin (Fig. 1). The evaluation was conducted in July, 1982, by FPM pathologists Jack Marshall, Borys Tkacz, and Ralph Williams with field assistance from NDF's Molly Sinnott, Pat Murphy, and Ronan Thornhill.

MATERIALS AND METHODS

The evaluation began as a two-stage survey involving aerial photography, followed by ground evaluations. Aerial photographs of the areas along SR's 28 and 431 were interpreted to identify amounts and distribution of obvious damage or mortality. Ground evaluations to verify photo-interpretations and to determine cause, extent, and site associations of roadside vegetation damage or mortality were then conducted. The term "damage" refers to live trees exhibiting abnormally colored or formed foliage or characteristic signs or symptoms of biotic pests or abiotic factors.

Aerial Photography

Vertical aerial photography of the roadways was obtained by the Pacific Southwest Region's aerial survey specialist, Jule Caylor. Nine-inch by nine-inch format aerocolor negative 2445 film was used and positive prints for field use were made therefrom. Photographs were taken on September 15, 1981, at an approximate scale of 1:3500-1:4500. Interpretations were made for dead or discolored trees along a 200-foot wide strip on both sides of the roadways. The wide strip was interpreted so that damage within and beyond the influences of highway-associated factors including dessication, particulate abrasion, and salt toxicity could be compared.

Ground Evaluations

Ground evaluations were conducted over a two-week period in July 1982. Initially, vegetation damage and mortality along several small sections of highway were compared to that identified on the photographs. It was readily apparent that a large proportion of damaged vegetation, especially lightly damaged or understory trees could not be detected using the photographs. Therefore, it was necessary to ground survey the entire area. Due to time constraints, as well as reports (2,5,7) indicating that most salt damage along highways occurs within 50 feet of the roadway, the width of survey strips was reduced from 200 feet to 100 feet on each side of the roadways.

State Route 431

After reviewing the aerial photographs and observing roadside vegetation during a preliminary drive from Incline Village to the Mt. Rose Campground, a distance of nine miles, I decided that since coniferous vegetation adjacent to the roadsides was often sparse and damaged trees were so infrequent that a thorough ground survey was not warranted. Therefore, damage and mortality was recorded on the photographs while driving slowly along this route. Frequent stops were made to determine probable cause of conifer

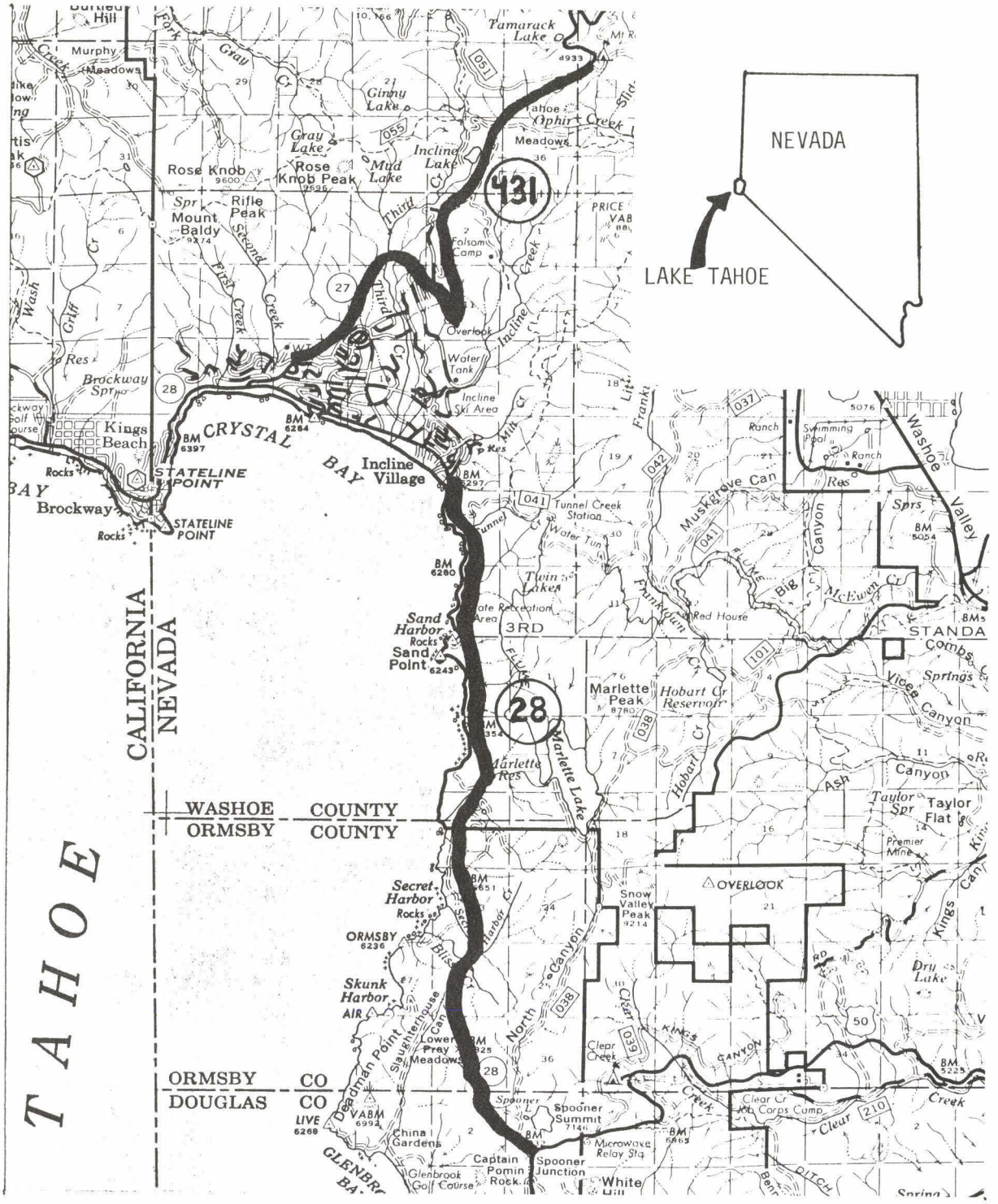

Figure 1. Surveyed portions of Nevada State Routes 431 and 28, Lake Tahoe Basin.

damage or mortality.

State Route 28

Because of the prevalence of obviously damaged vegetation, SR 28 was intensively sampled. A two-person crew walked the roadside examining and mapping on the photographs all trees within 100 feet of the pavement which were dead or exhibited other abnormalities including foliage discoloration, brooming, etc. The following information was recorded for each tree examined:

1. Species
2. Horizontal distance from edge of pavement (to nearest five feet)
3. Upslope or downslope
4. Slope percentage (to nearest five percent)
5. Crown condition (fading, red, or dead--with or without foliage)
6. Tree diameter (to nearest even inch)
7. Causal agent of damage or mortality, and
8. Salt damage class (Appendix), if so afflicted

Assessment of damage agent associated with mortality or foliar damage involved examining affected trees for all types of biotic and abiotic agents. Identification of abiotic agents was generally based on descriptions by Miller (3) and Scharpf and Srago (7,8).

Identity of biotic agents was based on characteristic signs and/or symptoms of pests present.

Prior to the survey, foliar samples from trees considered salt damaged were sent to Dr. John Woo, Intermountain Forest and Range Experiment Station (INT), Moscow, Idaho, for histological preparation. Preparations were then sent to Dr. Clinton Carlson, INT, Missoula, Montana, for interpretation as to presence of salt damage within needle tissues.

So that progression of damage can be followed, all damaged trees identified on the ground were located on the aerial photographs and assigned numbers corresponding to those on data sheets.

RESULTS

As indicated earlier dead or damaged trees could not be reliably identified on photographs. Therefore, photographs were used only to document location of dead or damaged vegetation.

Discolored foliage samples sent for histological evaluation of salt damage were confirmed as being salt damaged. Based on foliar discoloration patterns, I suspect other abiotic factors, particularly those associated with dessication or particulate abrasion, may also be associated with foliage discoloration, but to a lesser degree.

Since damage symptoms of these factors are not easily distinguished from those of salt, all foliar discoloration not associated with biotic factors

will be combined into a "salt damage" grouping. In-depth, individual tree studies would be needed to quantify damage by each factor.

State Route 431

A total of 135 dead or damaged trees was recorded within the 100-foot strips adjacent to the nine-mile portion of SR 431 evaluated. Table 1 lists mortality and damage agents by tree species and numbers of dead and damaged trees.

Mortality. A total of 12 dead trees, all white fir, was recorded; nine of these were snags. Of the three recently killed trees, two were killed by the fir engraver beetle (Scolytus ventralis LeConte) and one by both fir engraver beetle and annosus root disease (Fomes annosus (Fr.) Cke.).

Damage. A total of 123 damaged trees was recorded. Of these, 116 displayed signs of salt damaged foliage. Most (64 percent) of the salt damaged trees had only light levels of damage (Table 1). Although lodgepole pine was the most frequently affected species, with most being saplings growing in dense clusters within ten feet of the roadside, particulate abrasion may have been the primary cause of damage. Other than the damage observed on these dense clusters, lodgepole pine did not display salt damage elsewhere, and this species appeared to be more tolerant of salt than other species surveyed.

The only other damage agent recorded was broom rust (Melampsorella caryophyllacearum Schroet.) on red fir. Although detected only seven times within the survey strips, signs of this pathogen were readily observed beyond the survey boundaries.

State Route 28

A total of 2,150 dead or damaged trees was recorded within 100 feet on either side of the 11-mile stretch of SR 28 surveyed. Table 2 lists mortality and damage agents by tree species and numbers of dead and damaged trees. Mortality and damage totals do not sum to actual totals because some trees were affected by several agents. Most of the mortality was either scattered or located in small groupings, and the major damage agents were generally distributed throughout host type.

Mortality. A total of 253 dead trees was recorded. Most (59 percent) were snags which had been dead for several years and in which cause of death could not be determined. Cause of death of the other trees was attributed primarily to biotic agents, including bark beetles, root pathogens, and dwarf mistletoe. Of the abiotic factors identified as being associated with mortality, build-up of road berm appeared to be the most significant.

Mortality from bark beetles included 27 Jeffrey pine killed by the Jeffrey pine beetle (Dendroctonus jeffreyi Hopkins) and ten white fir killed by the fir engraver beetle.

Mortality from root pathogens included 36 white fir associated with annosus root disease and ten Jeffrey pine and two white fir associated with Armillaria root rot (Armillaria mellea (Vahl ex Fr.) Quél.).

Table 1. Numbers of and agents responsible for conifer mortality and damage along surveyed portions of Nevada State Route 431.

TREE SPECIES	MORTALITY			DAMAGE				
					SALT			
	Fir Engraver Beetle	Annosus root disease	Snags	Broom Rust	Light	Moderate	Severe	Total Salt
Jeffrey Pine					7	3	10	20
Lodgepole Pine					51	11	1	63
Sugar Pine					1			1
Incense Cedar					5	7		12
Red Fir				7	2	4		6
White Fir	3	1 1/	9		8	5	1	14
TOTAL	3	1	9	7	74	30	12	116
% of 12 dead or 123 damaged	25	8	75	6	60	24	10	94

1/ Found in association with white fir killed by fir engraver beetle.

Table 2. Numbers of and agents responsible for conifer mortality and damage along surveyed portions of Nevada State Route 28.

TREE SPECIES	MORTALITY								DAMAGE																	
	BIOTIC					ABIOTIC			BIOTIC														ABIOTIC				
	Jeffrey Pine Beetle	Fir Engraver Beetle	Annosus root disease	Armillaria root rot	Dwarf Mistletoe	Mechanical	Road berm buildup	Snags/unk. cause	Jeffrey Pine Beetle	Fir Engraver Beetle	Jf. Pine Needleminer	Red Turpentine Beetle	Cal. Flathead Borer	Scale	Pitch Moth	Annosus root disease	Dwarf Mistletoe	True Mistletoe	Broom Rust	Western Gall Rust	Elytroderma	Dieback/Decline	Animal	Mechanical	Road berm buildup	Frost	Salt
Jeffrey Pine	27			10	4	1	2	63	2		1	1	5		2		316			2	2		1	6	15		1,049
Lodgepole Pine								2						1													39
Sugar Pine								1																			14
Incense Cedar							9	46										24	15			56		3	1		175
Red Fir																											0
White Fir		10	36	2			8	37		3						5								2	2	10	263
TOTALS	27	10	36	12	4	1	19	149	2	3	1	1	5	1	2	5	316	24	15	2	2	56	1	11	18	10	1,540
1/ % of 253 dead or 1,897 damaged	11	4	14	5	2	1	8	59	0	0	0	0	0	0	0	0	17	1	1	0	0	3	0	1	1	1	81

1/ Actual totals of 253 dead and 1,897 damaged trees do not correspond with "TOTALS" row, if added above, as some trees were killed or damaged by more than one causal agent.

Western dwarf mistletoe (Arceuthobium campylopodum Engelm.) was responsible for the death of four Jeffrey pine.

Downslope accumulation of road berm was the apparent cause of death of 19 seedling/saplings, nine incense cedar, eight white fir, and two Jeffrey pine.

Damage. A total of 1,897 damaged trees was recorded (Table 2). Most damage was from abiotic causes (Fig. 2). Damage from several different factors was occasionally found on the same tree.

Foliar discoloration, mostly typical of salt damage, was recorded on 1,540 trees. Numbers of conifers with salt damage are presented by tree species and salt damage class in Table 3. Although salt damage was noted most frequently on Jeffrey pine, it was observed on all conifer species except red fir, an infrequently encountered species in the survey.

While frequency and distribution of salt damage on roadside shrubbery were not determined, shrubs suspected of being damaged by salt (8,9) included greenleaf manzanita, golden chinquapin, mountain mahogany, bitterbrush, and rabbit brush. Most affected shrubs were immediate to the roadsides; however, damage to greenleaf manzanita was observed up to 50 feet from the road.

Other abiotic factors contributing to foliar damage were build-up of road berm, mechanical injury, and frost.

Various biotic agents also caused conifer damage. Insects associated with minor amounts of damage included a needleminer (? Coleotechnites sp. ?), California flathead borer (Melanophila californica Van Dyke), and a pitch moth (? Vespamima sp.?), all on Jeffrey pine and pine needle scale (Chionaspis pinifoliae (Fitch)) on lodgepole pine (Table 2).

Damage associated with pathogens on Jeffrey pine included western dwarf mistletoe, Elytroderma needle disease (Elytroderma deformans (Weir) Darker), and western gall rust (Endocronartium harknessii (J.P. Moore) Hirat.). Pathogens on incense cedar included incense-cedar rust (Gymnosporangium libocedri P. Henn.), true mistletoe (Phorodendron juniperinum var. libocedri Engelm.), and an unidentified dieback/decline.

Western dwarf mistletoe was the most frequently encountered biotic agent of those mentioned above. Most (60 percent) dwarf mistletoe-infected trees were in infection classes 2 and 3 (Hawksworth 6-class system) (1), representing light to moderate infection intensities.

Associations between Mortality/Damage and Roadside. Both distance from roadside and tree location, up-or downslope, were evaluated to ascertain their association with tree mortality or damage.

1) Distance from roadside.
   Predominant type of mortality or damage agent, size class affected, and incidence differed between 0-50 and 50-100 feet intervals from the roadsides. The following table briefly summarizes these differences. Note that incidence is reported as observed trees per acre, and not as an annual rate.

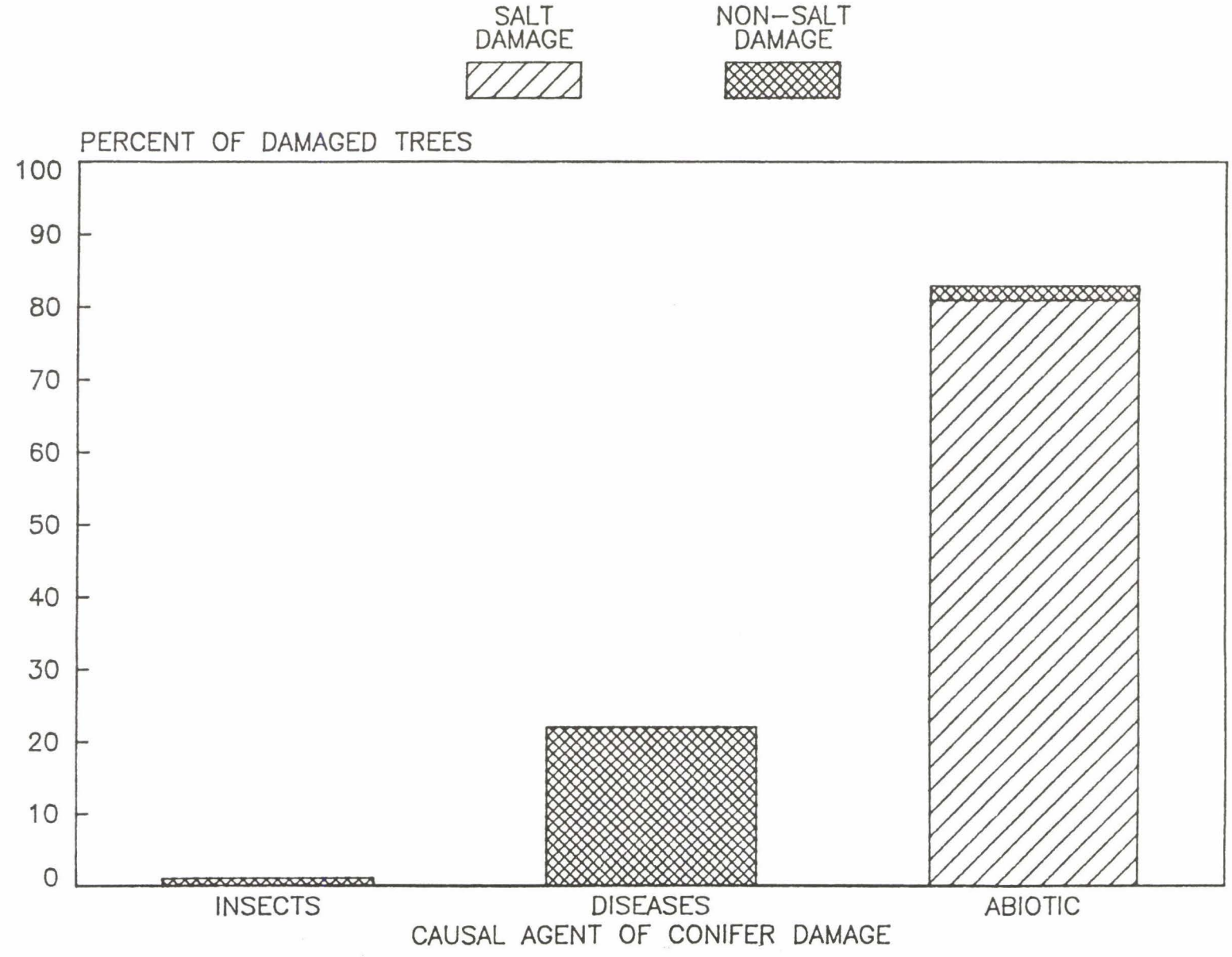

Figure 2. Percentage of damaged trees with insect, disease, or abiotic causes of damage. Salt damage has been highlighted in the abiotic incidence bar. Bar percentages do not sum to 100 % because some trees had more than one causal agent present.

Table 3. Numbers of salt damaged [1/] trees by tree species and damage levels.

TREE SPECIES	SALT LEVELS			TOTAL
	Light	Moderate	Severe	
Jeffrey Pine	341	369	339	1,049
Lodgepole Pine	25	8	6	39
Sugar Pine	3	4	7	14
Incense Cedar	63	56	56	175
Red Fir [2/]	0	0	0	0
White Fir	71	86	106	263
TOTAL	503	523	514	1,540
% of total	33	34	33	100

[1/] Refers to those trees with foliar discoloration typical of salt damage.

[2/] Very few red fir were located within survey limits.

Table 4. Summary of generally affected size classes, type of causal agent, and incidence of mortality and damage to conifers within 0-50 and 50-100 feet of Nevada SR 28 surveyed.

Association Variable		0-50 ft	50-100 ft
size class :	mortality	0-6"	7-12"
	damage	0-6"	0-6"
causal agent:	mortality	biotic	biotic
	damage	abiotic	abiotic and biotic
incidence :	mortalty	1.2	0.7
(trees/acre)	damage	11.9	2.3

Within 50 feet of the roadway the major mortality agents were Jeffrey pine beetle, Armillaria root rot, and annosus root disease, while the major damage factors or agents, although low in numbers compared to the 0-50 foot interval, were salt damage and western dwarf mistletoe.

2) Slope.
Of the 1,540 salt damaged trees 75 percent were downslope and 24 percent upslope from the road. Ninety percent of salt damaged trees downslope of the road were within 55 feet of the roadside, while 90 percent of the salt damaged trees upslope of the road were within 35 feet of the roadside (Fig. 3). Although average downhill and uphill slope percentages (56 and 45 percent, respectively) varied, no correlation was drawn between salt damage incidence and slope percentage.

DISCUSSION

As distance from the roadsides increased, numbers of dead and, particularly, damaged trees decreased. Generally, most of the mortality and damage was found within 50 feet either side, but primarily downslope of the roadsides. These findings are consistent with other studies conducted in the Lake Tahoe Basin (2,7). Although mortality and damage amounts were both greater at the closer distances, perhaps only the damage amounts are of concern. Conifer mortality may be insignificant in view of the number of trees/acre and the predominantly small diameter size class affected. However, foliage discoloration due to salt damage was alarmingly noticable on many trees immediate to portions of SR 28 surveyed. This damage is of concern for two reasons:

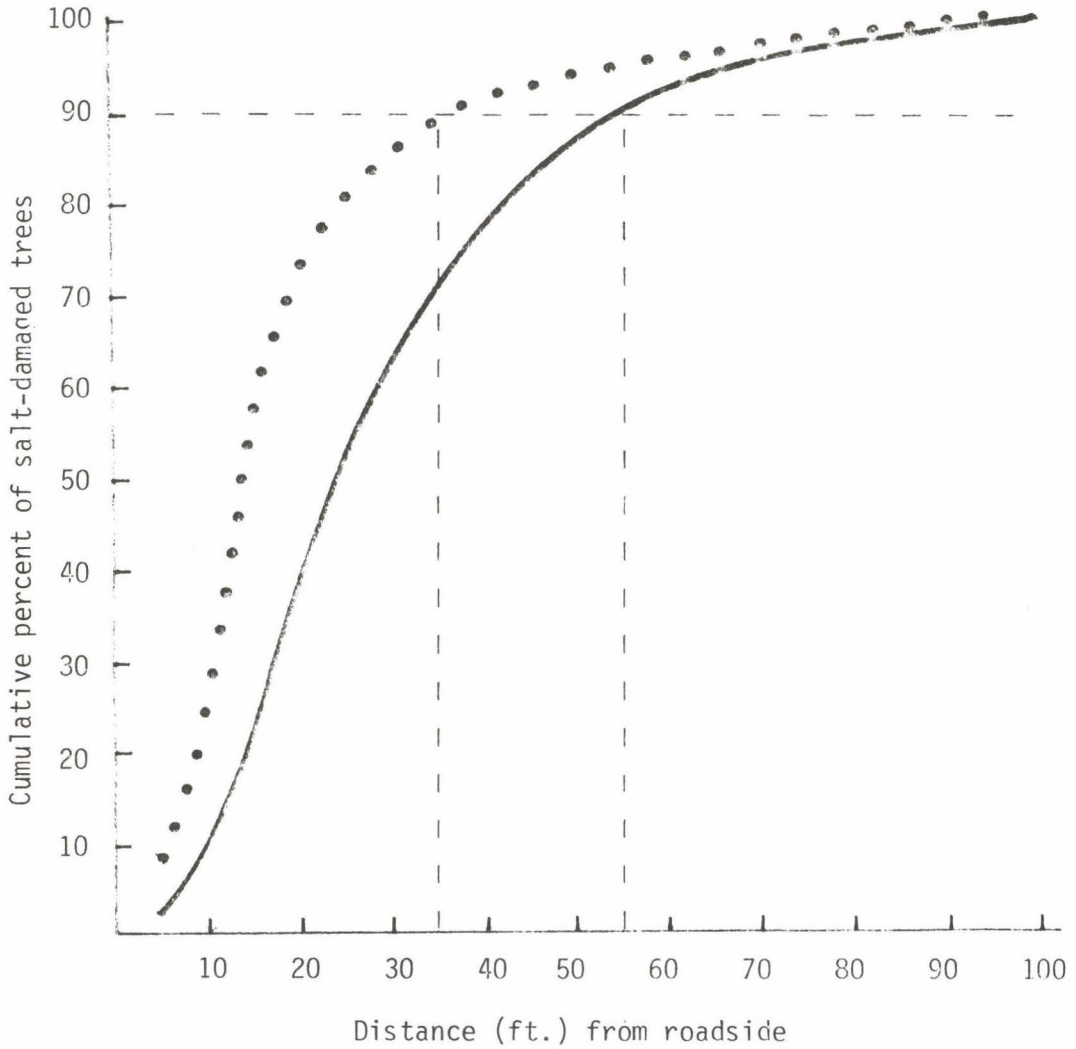

Figure 3. Cumulative percentage of 362 upslope (dotted line) and 1,178 downslope (solid line) salt-damaged trees at increasing distance from Nevada State Route 28. Dashed line intercepts represent distances within which 90 percent of salt-damaged trees were found for the respective slopes.

1) visual quality is impaired, and
2) damage may predispose trees to mortal attacks by various biotic agents.

As for the first concern, the amount of visual quality impairment can be reduced by several means, most of which may be costly. These means are discussed in the ensuing alternatives section. However, if local land managers believe the degree of visual quality impairment along SR 28 does not warrant a change in silvicultural or highway management, no change would be recommended.

The second concern addresses questions left unanswered by this survey:

1) do the particular types and/or degrees of conifer damage detected in this survey predispose trees to mortality, and
2) if so, would the rate of mortality be greater than that for trees in nearby stands removed from the influences of highway associated damage factors: i.e., those with a "natural" rate of mortality?

These questions could be answered by means of periodic monitoring. Trend plots could be established in nearby stands of similar composition to determine a natural rate of mortality. This rate could be compared to the mortality rate of those trees which were observed damaged and identified on photographs during the 1982 survey. It would also be valuable to collect information on cause of death in both trend plots and along SR 28. This information could ascertain whether trees abiotically damaged in 1982 will eventually die from such damage or repeated damage, or become predisposed to various biotic agents at a greater rate than found under "natural" conditions.

ALTERNATIVES

1. No change. Current application rates of deicing materials would be continued. Similar amount of damage and, assuming damaged trees are predisposed to mortal attacks by various biotic agents, perhaps an increase in mortality may occur. Newly killed trees could be salvaged if merchantable.

2. Change Mechanics of Deicing Highways. Consider the use of darker abrasive materials to allow greater solar absorption. Consider various application rates or kinds of salts and/or abrasives. Some of these changes may be costly to equipment and storage conversions; however, long-term benefits to vegetation may be considered.

3. Disallow Use of Deicing Salts. The use of abrasives, only, may be experimented on short sections of the roads to determine whether various abrasives may give comparable deicing results as abrasives with deicing salts. However, as mentioned earlier in my definition of "salt damage," an unidentified amount of the foliar damage was likely the result of abrasion

by road or ice particulates. Therefore, the use of abrasives alone, will not totally eliminate the amount of roadside "salt damage."

4. Species Conversion. Remove roadside trees chronically or severely affected by salt damage before they are killed by various biotic pests. Certain species appeared to be less tolerant of salt and hence, may become more readily predisposed to biotic agents. The least tolerant species appeared to be sugar pine and incense cedar, moderately tolerant species were Jeffrey pine and white fir, and most tolerant was lodgepole pine. I did not observe enough red fir from which to base an opinion. Therefore, if any thinning or tree planting operations are planned or considered to improve the vigor of roadside conifers, discriminate against low vigor sugar pine and incense cedar, or plant or favor the regeneration of the moderately or highly resistant species listed above. Laboratory salt tolerance tests might be conducted on all the species surveyed to determine actual salt tolerance levels relative to each other, or in comparison with my observations before deciding which species to plant or favor.

RECOMMENDATIONS

Currently, mortality levels are minimal along surveyed portions of SR 28. However, these areas should be annually or biennially monitored to determine if future mortality rates will be significantly different between trees observed with high levels of salt damage in 1982 and similarly located unaffected or lightly affected trees. If the heavily salt damaged trees have an insignificant mortality rate difference, perhaps no change in highway or vegetation management is warranted. Alternative No. 1 would then be recommended. During salvage operations mentioned in Alternative No. 1, newly cut stump surfaces should be topically treated with granular borax to prevent colonization by Fomes annosus spores. When left untreated stumps are likely portals for the spread of annosus root disease onto roots of adjacent healthy trees.

Should current amounts of roadside damage (11.9 trees/acre) or future mortality rates along SR 28 be unacceptable, alternative No. 4 would be recommended.

Mortality and damage amounts along portions of SR 431 surveyed are insufficient to warrant any changes in present highway or vegetation management.

ACKNOWLEDGEMENTS

I wish to express thanks to the following for their laboratory or field assistance: Dr. John Woo, INT, Moscow, Idaho; Dr. Clinton Carlson, INT, Bozeman, Montana; Jule Caylor, FPM, Pacific Southwest Region; Dr. Ralph Williams and Borys Tkacz, FPM, Intermountain Region; and Pat Murphy, Ronan Thornhill, and Molly Sinnott, Nevada Division of Forestry, Carson City, Nevada.

LITERATURE CITED

1. Hawksworth, F. G. 1977. The 6-class dwarf mistletoe rating system. USDA For. Serv., Rocky Mtn. For. and Range Exp. Sta., Gen. Tech. Rpt. RM-48, 7 pp.

2. Leiser, A. T., J. L. Paul, and R. Raabe. 1980. Highway operation and plant damage. Dept. of Environm. Hort., UC Davis and Cal. Dept. of Trans. Rpt. No. FHWA/CA/TL-80/03. 264 pp.

3. Miller, P. R. 1978. Abiotic diseases. Pages 5-41 in R. V. Bega, Diseases of Pacific Coast conifers. Agriculture Handbook No. 521. 206 pp.

4. Pittelkow, B. 1980. Highway deicing salt survey. USDA For. Serv. and Nevada Div. of For. Memorandum (8/8/80). 4 pp.

5. Rich, A. E. and N. L. Lacasse. 1964. Salt injury to roadside trees. Forest Notes, Concord, N. H. No. 80:3-5.

6. Scharpf, R. F. and R. V. Bega. 1981. Elytroderma disease reduces growth and vigor, increases mortality of Jeffrey pines at Lake Tahoe Basin, California. USDA For. Serv., Pacific SW For. and Range Exp. Sta. Res. paper PSW-155. 67 pp.

7. Scharpf, R. F. and M. Srago. 1974. Conifer damage and death associated with the use of highway deicing salt in the Lake Tahoe Basin of California and Nevada. USDA For. Serv., Pacific SW Region, For. Pest Control--Tech Rpt. 1. 16 pp.

8. Scharpf, R. F. and M. Srago. 1978. How to diagnose road-salt injury in California conifers. USDA For. Serv., Pacific SW For. and Range Exp. Sta. 8 pp.

9. Westing, A. 1969. Plants and salt in the roadside environment. Phytopathology 59:1174-1180.

SALT DAMAGE CLASSES[1/]

Light damage	- damage to one-third or less of the foliage and only the very tips of the needles showing tipburn.
Moderate damage	- one-third to two-thirds of the foliage damaged and one-half or less of the length of the damaged needles on pines showing tipburn.
Severe damage	- more than two-thirds of the foliage damaged, and on pines more than 50 percent of the needle length showing tipburn. Trees that were completely brown and apparently dead were included in this category.

1/ Scharpf and Srago (7).